EFFECT OF WATER EDUCATION

ON REDUCING RESIDENTIAL CONSUMPTION

IN SAN ANTONIO, TX

A Thesis

by

JEREMY JOSEPH RICE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2009

Major Subject: Water Management and Hydrological Science

EFFECT OF WATER EDUCATION

ON REDUCING RESIDENTIAL CONSUMPTION

IN SAN ANTONIO, TX

A Thesis

by

JEREMY JOSEPH RICE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Approved by:

Chair of Committee:	Ronald Kaiser
Committee Member:	Kelly Brumbelow
	Robert Knight
Intercollegiate Faculty Chair:	Ronald Kaiser

August 2009

Major Subject: Water Management and Hydrological Science

ABSTRACT

Effect of Water Education
on Reducing Residential Consumption
in San Antonio, TX. (August 2009)
Jeremy Joseph Rice, B.S., Texas A&M University
Chair of Advisory Committee: Dr. Ronald Kaiser

Education is touted as one of the most effective and inexpensive measures for reducing water consumption for major cities. Coupled with additional water reducing strategies this education can have a significant impact. While, this is a generally accepted principle in the water resources community it has been difficult to accurately quantify the savings. Studies attempting to quantify reductions from these programs have been limited to small samples of neighborhoods. San Antonio is recognized as one of the leading conservation programs in the country at reducing the consumption of its customers. This study focused on over 3,000 customers in San Antonio who were classified as high-end users. The average monthly consumption for this group in June of 2006 exceeded 60,000 gallons per month. Each customer was sent an educational packet by mail with information to conduct an audit of the water use indoors and outdoors. Many of the customers used a free service allowing a trained professional of the San Antonio Water System to conduct their audit at no charge. Three groups were identified (1) those who received a educational packet, (2) those who conducted a home audit and reported they had conducted an audit, (3) those who had a free audit conducted by a trained technician. The water consumption for six months was tracked and compared to the previous year's consumption. Each of the three groups showed savings with those in the third group showing the greatest savings. Lastly, a cost analysis was conducted showing the effectiveness of the program in reducing consumption by cost.

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Over the past 20 years, conservation has become a cost-effective way for cities to improve the reliability and availability of water supplies. Each gallon saved by a homeowner is one less gallon that needs to be secured from another resource. Few cities understand the finite nature of water as fully as San Antonio, Texas. As such, the city has implemented an extensive water conservation program to improve the reliability of its water supply. Consumption has decreased from 159 gallons per capita (gpcd) in 1990 to around 140 gpcd in 2004 (TWDB, 7/14/2008). The current population of 1.25 million people within the city limits is expected to increase 85%, reaching 2.1 million in 2060 based on projections from the 2006 Region L Water Plan (Group 2006). Demand is expected to increase by 69% from 188,479 acre-feet in 2000 to 317,727 in 2060 (Group 2006). The Edwards Aquifer will not provide the water to meet this growth generated demand (Bureau 2005). This paper examines the savings of a water audit program targeted at the top one percent of all residential customers.

Residential water consumption between indoor and outdoor uses varies throughout the country. Generally, outdoor water use is lowest in the east and highest in the arid southwest and western regions of the country. Vickers (2001) noted that outdoor use as a proportion of single family residential use ranges from 10 % in Waterloo, Ontario to as high as 75% in Scottsdale, Arizona. An American Water Works Association. study of major cities in the southwest found that nearly 60% percent of water was used outdoors.(Mayer 1999).

Municipal water conservation programs focus on reducing residential, commercial and industrial consumption. Residential water conservation relies on five main strategies including (1) education programs, such as media campaigns and school educational efforts; (2) retrofit programs replacing appliances with lower consumption alternatives; (3) outdoor consumption restrictions such as time of day or day of week limitations; (4) rebate programs encouraging a change of landscape material to drought tolerant native landscapes and (5) water pricing. San Antonio has employed all five conservation strategies. Currently, the San Antonio Water System (SAWS) offers

---

This thesis follows the style of the Journal of the American Water Resources Association.

landscape rebates, appliance rebates (washing machines, hot water on demand), free appliances (toilets, low flow showerheads, aerators), educational programs for all grade levels, free audits of home and irrigation systems, and the enforcement of water waste. Conservation pricing has already been implemented in San Antonio with the top customers paying a higher rater for water consumed using an increasing block rate structure. All of the customers in this study fall under the fourth and most expensive tier of this rate structure. In many cases the use of an increasing block rate structure for these users has not resulted in a significant reduction in their usage.

The Top 1% of customers in San Antonio remained one of the few groups who had not bought into the conservation message. Customers in this category rarely participated in the many conservation programs offered by the San Antonio Water System. In addition to the low participation in conservation programs these customers were difficult to reach with mandatory restrictions due to the location in gated communities. This program was an effort to achieve savings in one area that was not being reached through the existing San Antonio Water System Conservation program.

"Resident's Assessment of an Urban Outdoor Water Conservation Program in Guelph, Ontario" (Atwood et al, 2007) evaluated the perceptions and effectiveness of a conservation program in this Ontario City. Outdoor water restrictions were implemented to reduce water consumption during periods of drought with escalating restrictions as drought conditions intensified. These restrictions included both time of day as well as day of the week restrictions similar to restrictions in San Antonio. Surveys were sent to three area neighborhoods to randomly selected households to evaluate their assessment of the effectiveness of the restrictions. Results of the study indicated broad support for the program which showed significant water savings. The variables that most greatly affected the assessment of the program were neighborhood, gender and environmental attitude. While overall the program was successful the surveys indicated that a majority of the residents did not feel that the program was implemented effectively and fairly.

The impact of price on water consumption, while uncertain, has been evaluated in several studies. In 2003, Dalhuisen et al. evaluated 64 studies on the impact of increased water rates on consumption. Results of the study showed that water demand was reduced by rate structures with increasing block rates that progressively increased rates as the volume of water increases. However, it has been the experience in San Antonio that many of the highest water consumers, including those in this study are able to afford the rates at the highest rate block. Thus non-price conservation measures are needed to have an impact on high-consumption customers.

Studies of non-price related conservation programs have been conducted throughout the United States and the world. One study that evaluated non-price measures in Colorado showed these measures whether voluntary or mandatory do have an impact on water consumption (Kenney 2004). Eight Colorado cities that implemented varying levels of restrictions during a drought were evaluated for the impact on water consumption. Between 18% and 56% in water savings were achieved through mandatory outdoor water restrictions. Voluntary restrictions showed reductions between 4% and 12%.

The literature shows that mandatory outdoor water restrictions have the greatest impact on water consumption. In conjunction with voluntary water appliance rebate/retrofit programs and increasing block rate pricing structures the water consumption in a municipality can be reduced. San Antonio, which has already implemented these varying water conservation programs, looked at water audits of residences to achieve immediate savings in preparation for drought restrictions and mandatory outdoor watering restrictions.

1.1 San Antonio Water Audit Program

A residential water audit is a survey of single-family and multi-family customers to provide information to them about methods to reduce indoor water use through replacement of inefficient showerheads, toilets, aerators, clothes washers, and dishwashers. If the customer has an automatic irrigation system, the survey includes an evaluation of the schedule currently used and recommends any equipment repairs or changes to increase the efficiency of the irrigation system." (Texas WCTF 2004). The literature review of water audits showed a wide range of programs with varying degrees of savings.

In California, the Contra Costa Water District implemented audits targeted towards high summer water users. Audits included an analysis of indoor appliances and investigation and adjustment of irrigation systems. Audits conducted for 1999 – 2001 were evaluated. Total savings for the three years amounted to 11,393 gallons per participant per year. The estimated cost per acre-ft of water saved was $787. (Little 2003)

The City of Austin, Texas offered customers free irrigation evaluations to check for leaks while informing customers of proper watering schedules. During the summer of 2005 the Austin Water Conservation Department provided the top 1,000 residential customers with an estimate of the water requirement for their landscape based on evaoptranspiration (ET) data. Estimates were developed using GIS to determine the amount of landscaping needing irrigation. An initial comparison of water use amounts the month before and after the irrigation audit showed a 37.5 percent reduction. Two months after the audits were conducted; the water use reduction was approximately 19.4 percent. (Dewess 2005)

A landscape runoff reduction study was conducted by the Irvine Ranch Water District in California (Diamond 2003). The district studied the results of a neighborhood that replaced their traditional irrigation controllers with ET controllers and a second neighborhood was provided education materials and a suggested irrigation schedule. After 18 months of studying the five neighborhoods the results from the study indicated that the ET controller group showed a water savings of 41 gallons per day or a 10% reduction compared to the control neighborhoods. The education only neighborhood showed a savings of 28 gallons per day or 6% of total water use. (Diamond 2003)

The city of Denton, Texas offers free water audits upon customer request. In Denton the water audit program consists of an on-site walkthrough inspection of the irrigation system for leaks, review of conservation water habits and installing low-flow devices if the owner wished. In October 2003, Denton had performed 102 of these audits. Water consumption of customers who have participated in the program was by 15% from their previous use (Inc. 2006). Denton has determined that this program is cost-effective when compared to the cost for new potable sources.

In 2006 the City of San Antonio pumped 66,299 million gallons up from 62,856 gallons in 2005. The conservation program in San Antonio began in 1992 and has slowly grown from a small department into one that has a budget of $6 million and several award winning programs. While significant progress has been made in reducing overall residential consumption, the top one percent of residential users has seemed immune to these conservation strategies. High-end residential users with large properties continue to use significant quantities of water even with enforcement. Efforts to target high-end residential users have become a priority for the San Antonio Water System. Approximately 3,200 customers were identified within the top one percent category with each customer consuming on average 63,000 gallons per month.

2. RESEARCH PROJECT DESIGN

The San Antonio Water System maintains a database of 300,000 residential customers. The database includes water consumption reported on a monthly and annual basis. A total of 3,273 customers were selected comprising the top one percent of residential water users in San Antonio. These users were identified based on their consumption for the months of May and June 2006. An average was calculated for over 300,000 residential customers within the SAWS system. The top 1% was identified by sorting the consumption and then selecting the top 3,273 customers. Table 1 shows the percentage of the top 1% by category of water use.

Table 1: Percent of Homes in the Study by Monthly Consumption

Category	Monthly Consumption (Gallons per month)	Percent
1	<30,000	48%
2	30,000 - 39,000	13%
3	40,000 - 49,000	12%
4	>50,000	27%

Each of the residential customers identified as Top 1% customers were mailed a packet. This packet included three things 1) letter identifying their average consumption for May/June 2006 along with their status as a Top 1% customer, 2) checklist to check for common household problems and leaks (see appendix). Through the checklist customers could schedule a free audit by a conservation technician to check for leaks. 3) letter from the CEO of the San Antonio Water System encouraging customers to look for ways to reduce consumption. Letters were mailed out in the middle of July 2006. Following the distribution of packets customers began to contact the conservation department with concerns which led to the scheduling of free residential audits. Audits were conducted by trained technicians using the same checklist sent out to the customers. Those customers who did not respond to the packet were not contacted following receipt of the packet and for the purposes of this study were used as an example of no response.

The results of three different education techniques on water consumption in the targeted one percent group were evaluated. Monthly consumption in 2005 was used as a base to evaluate any 2006 use reductions. The different categories of customers were then compared based on their consumption (no response, self audit, SAWS audit). Overall, the total reduction from the program was calculated to determine if one method was more effective at reducing consumption. Descriptive statistics and analysis of variance were used to determine if there are statistically significant differences in consumption based on the (1) letter, (2) the checklist and (3) the water audit.

Checklists were collected from all of the participants in the program. All of the returned checklists from both the self-audits and the SAWS audits were evaluated for trends. The checklist encouraged a homeowner to examine every appliance within their home which could possibly waste water. Every customer who scheduled an audit had a similar process conducted at their home. Trained technicians would likely catch problems that a homeowner may not. The checklist and audit covered a broad area and helped to look for leaks within and outside a home. If leaks were detected, their locations were noted (indoor, outdoor) and a record was kept of the type of problem (toilet, shower, sink, irrigation system). Every home that had an irrigation system was identified to associate consumption variations due to outdoor watering. It is possible that audits conducted by SAWS technicians would lead to identifying a greater number of problems and lowered consumption following the audit (% reduction for audits).

During the audits of homes auditors would recommend programs available to help reduce consumption. Any noticeable leaks were identified for the homeowner to fix. In most cases the homeowner would notify SAWS through a written letter that the leak had been repaired. Currently SAWS does not offer any rebates for leak repairs, only credits the identification of these leaks.

Appraisal district data for identified Top 1% Residential users was collected for property value, acreage, and living square footage from Bexar County Appraisal District Records. Overall, 3,212 were matched from a total of 3,289. Initially, the averages for each variable were calculated. Correlations between each of the variables and the consumption were evaluated using SPSS.

Two neighborhoods were selected with similar economic characteristics in the Top 1% group. Census tracts provided for the easiest access to this data through the U.S.

Census Bureau Website (Bureau 2005). Census tracts were selected that had similar economic characteristics to the neighborhoods with a high percentage of Top 1% customers (Appendix B). Verification can also be achieved by overlaying the census tracts on the map of the Top 1% customers. The same process used to compare the prior consumption of the 1% users to their consumption following the checklist was used in the comparison neighborhoods. The percentage reduction was used as a control since these customers did not receive a letter. Through this control the effect of the Top 1% identification program was evaluated.

The comparison neighborhoods also helped to control for drought restrictions that were instituted shortly after the distribution of the packets to the Top 1%. Any reduction in the control group should be a result of drought restrictions. By removing this amount from the amounts of the 1% sample a non-drought reduction attributed to the identification can be determined.

All of the data collected for this study was used by the San Antonio Water System staff. Consumption data were provided for each of the accounts for 2005- 2006. The checklist and audit data were compiled from files provided by San Antonio Water System staff. Analysis of all of the data was done using descriptive statistics focusing on means, averages, and ranges. SPSS software was used with Microsoft Excel to run the statistical analysis.

3. RESULTS AND DISCUSSION

Starting on July 20, 2006 Stage 1 drought restrictions were put in place for the San Antonio Metropolitan Area. Drought restrictions are implemented whenever the level at the J-17 well were below 650 feet (Figure 1). Restrictions remained in place continuing through December 2006. While these restrictions should have the desired effect of lowering consumption city wide, it was extremely difficult to determine if the 1% identification caused reduced consumption or the drought restrictions. With only a single month prior to the declaration of restrictions and the distribution of the letters it is hard to determine which had a greater impact on these users. It took an additional month to schedule and conducts the audits for these 1% users. Thus in some cases it may have taken an additional month for any reduction in consumption to occur.

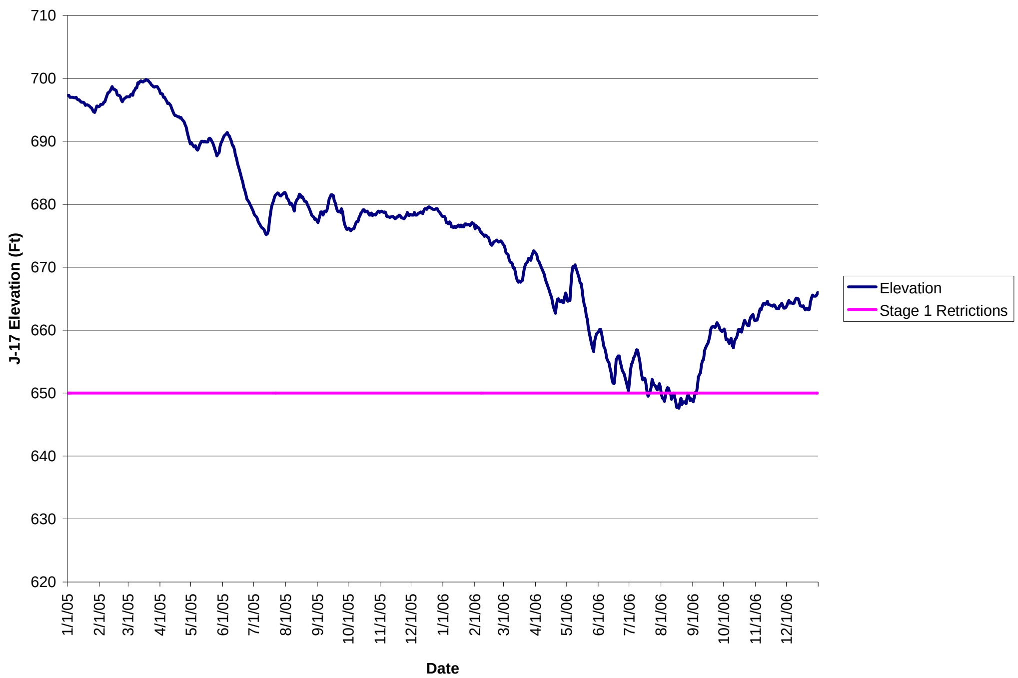


Figure 1 Aquifer Level at the J-17 Well

Additional circumstances may also contribute to a variation in consumption. Variations in temperature between the two time periods might affect consumption. Higher temperatures could cause increased consumption in comparison to historical usage. Temperature data were collected from the period (January 1, 2005 – Dec 21, 2006) to analyze any change in temperature. Looking at the data collected and creating a regression line it appears that temperatures increased slightly over the time period (Figure 2). In theory, this means that consumption should have increased slightly over the period. However, due to drought restrictions consumption may have decreased.

Another possible phenomenon noticed in San Antonio was the high consumption by users immediately before the declaration of drought restrictions. This can be caused by awareness that water usage will be curtailed during a drought so preventative measures are taken to over water right before restrictions are in place. Due to the multiple times levels dropped close to restrictions, users may have anticipated restrictions and increased their consumption (Figure 1).

3.1 Climatic Comparison

The temperature data for the years of 2005-2006 was collected and graphed. Non-linear regression lines were used to see if any considerable difference existed in temperature between the two time periods. The analysis of the temperature data indicated higher temperatures in 2006 than in 2005 (Figure 2). Rainfall amounts declined from 22.61 inches in 2006 to 16.56 in 2005 (Figure 3). Based on literature both factors, higher temperatures and reduced rainfall should lead to increased consumption. Variations in temperature, particularly during the dry summer months can have a major influence on the amount homeowners are using to maintain their landscape. Factoring in this data helps to understand any increases in consumption between the time periods before and after receipt of the packet.

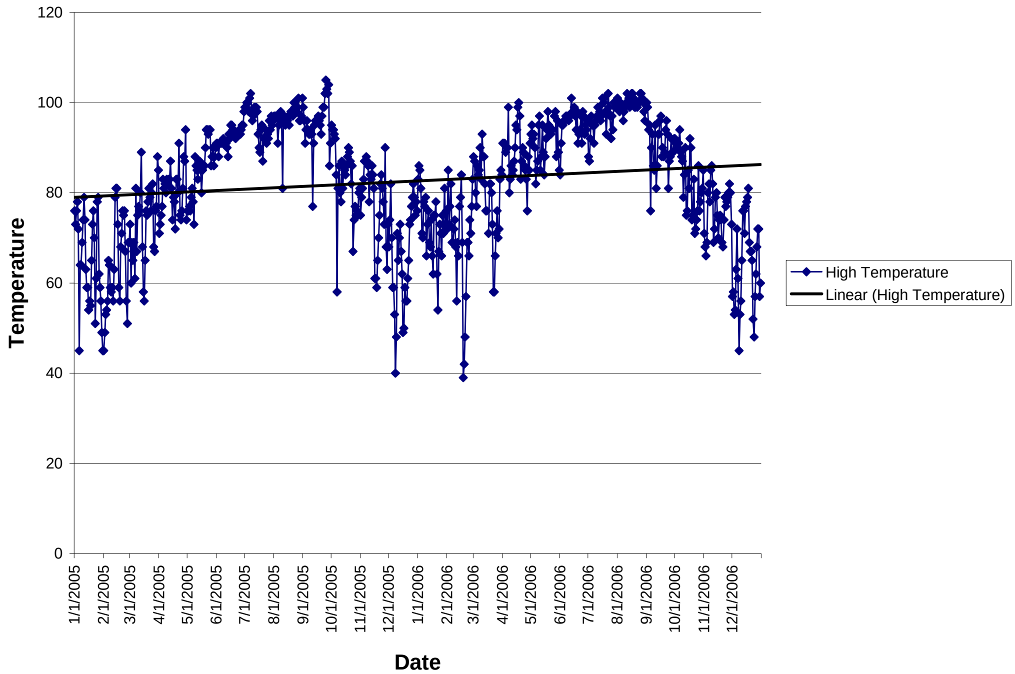


Figure 2 San Antonio High Temperature 2005-2006

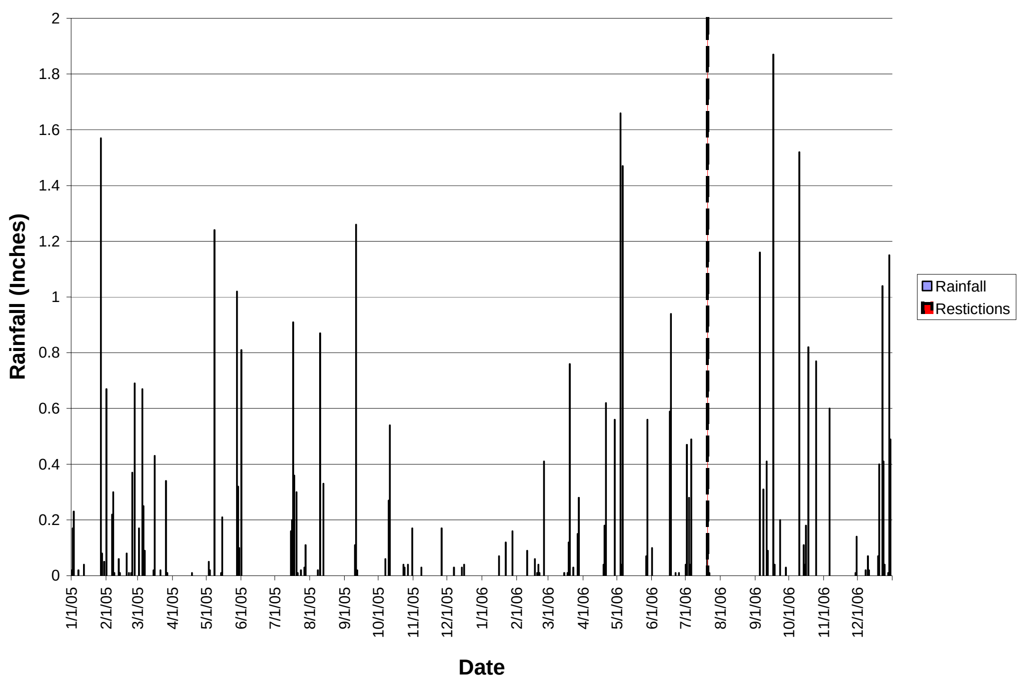


Figure 3 San Antonio Rainfall 2005-2006

Through the program 123 checklists were returned by customers while 183 audits were conducted by SAWS staff. The returned checklists from both the self-audits and the SAWS audits were evaluated for trends. Table 2 shows that over 100 self-audit checklists were returned and that nearly 200 SAWS audits were completed. The () represent the percentage of audits which had an indoor or outdoor leak. It shows that the SAWS staff generally found a greater number of leaks than what homeowners identified The number of irrigation systems indicates the number of homes which had an automatic sprinkler system..

Table 2: Self Audit and SAWS Audit Results

	Self Audit	**SAWS Audit**
Total	123	183
Indoor Leak	22 (18%)	64 (35%)
Outdoor Leak	24 (20%)	49 (27%)
Irrigation System	98 (80%)	162 (89%)

A correlation between types of homeowners were more likely to receive a SAWS audit or conduct their own audit. Figures 4 and 5 show the results. The greater the value of the home and the larger the area the greater the possibility a homeowner would ask for a SAWS Audit.

Report

Self Audit		Living Sq. Ft.	Prop_Value.
YES	Mean	3497.59	393617.93
	N	121	123
	Std. Deviation	1495.379	328754.680

Figure 4 Data on Self-Audit Group

Report

SAWS Audit		Living Sq. Ft.	Prop_Value.
YES	Mean	3888.69	505854.40
	N	181	182
	Std. Deviation	1261.436	331475.549

Figure 5 Data on SAWS Audit Group

The average for each of the variables available through the Bexar County Appraisal District was calculated. Table 3 shows the averages for this group. The averages indicate that the customers in the top 1% have high dollar large homes with large properties.

Table 3: Top 1% Appraisal District Averages

Acreage	1.3748
Living Sq. FT.	3915.6
Property Value	$480,961

This study examined the relationship between lot and house size and property values and water consumption. Data on lot and home size and value were derived from the records of the Bexar County Appraisal Districts. Regression analysis revealed that large lot sizes more closely correlates with higher residential water consumption (R^2=.086) whereas home size and property values have a smaller relationship to consumption. This finding is congruent with the literature related to outdoor water use in those larger lots with more grass and landscape material will consume more water. The exception to this is landscaping with drought resistant native plants.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.293[a]	.086	.086	.8330909

a. Predictors: (Constant), AvgGallons

b. Dependent Variable: Property_ACRE

Figure 6 Property Size to Consumption

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.275[a]	.076	.075	1919.8660

a. Predictors: (Constant), AvgGallons

b. Dependent Variable: Living Sq. Ft.

Figure 7 Home Size to Consumption

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.286[a]	.082	.081	387302.491

a. Predictors: (Constant), AvgGallons

b. Dependent Variable: Prop_Value.

Figure 8 Property Value to Consumption

It could be assumed that the larger homes on larger lots, which are worth more, would have the highest consumption. While the data did show a correlation amongst property value and size with usage some outliers did exist. It is most likely that the high end users with smaller lots and residences were among the top 1% due to some type of leak.

3.2 Tracking Consumption (July 2006 – December 2006)

Each of the 3,289 customer's consumption was pulled for six months following the distribution of the letters. The consumption for the entire year prior to May 2006 was collected. A percentage difference was calculated for the months following July 2006 to the prior consumption amounts from the period of July 2005 – December 2005. Every customer who returned a checklist or had an audit completed were compared against those with no response to determine significant differences. Those customers that returned a checklist were also compared to those who had an audit completed.

Each of the three groups identified in the study showed a reduction in their water consumptions compared to their previous year consumption. The three groups (No Action, Self-Audit and SAWS audit) are listed in Table 4. The months in red show an increase from the previous year consumption and the black indicates savings. It is important to note that during this entire period the City of San Antonio was under drought restrictions to reduce consumption. It also took the staff a significant period of time to conduct the audits. Figure 9 is a graphical representation of Table 4. Figure 10 shows the total consumption for each of these groups from Jan 2005 through December 2006.

Table 4: Monthly Reduction by Category

	Aug_Reduction	Sep_Reduction	Oct_Reduction	Nov_Reduction	Dec_Reduction
No Action	13353.89	6006.99	11490.02155	7897.111448	4190.359933
Self-Audit	10509.84	1934.11	12881.89431	9652.341463	5407.081301
SAWS Audit	12840.36	2293.30	19548.68852	11331.89071	10248.55191

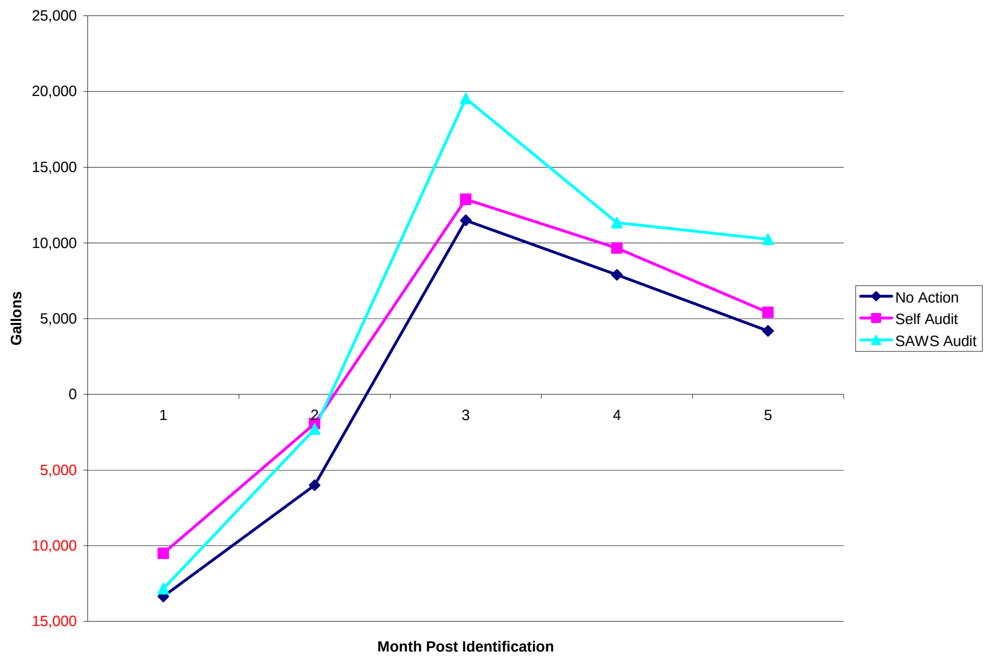


Figure 9: Average Monthly Consumption Reduction 2006

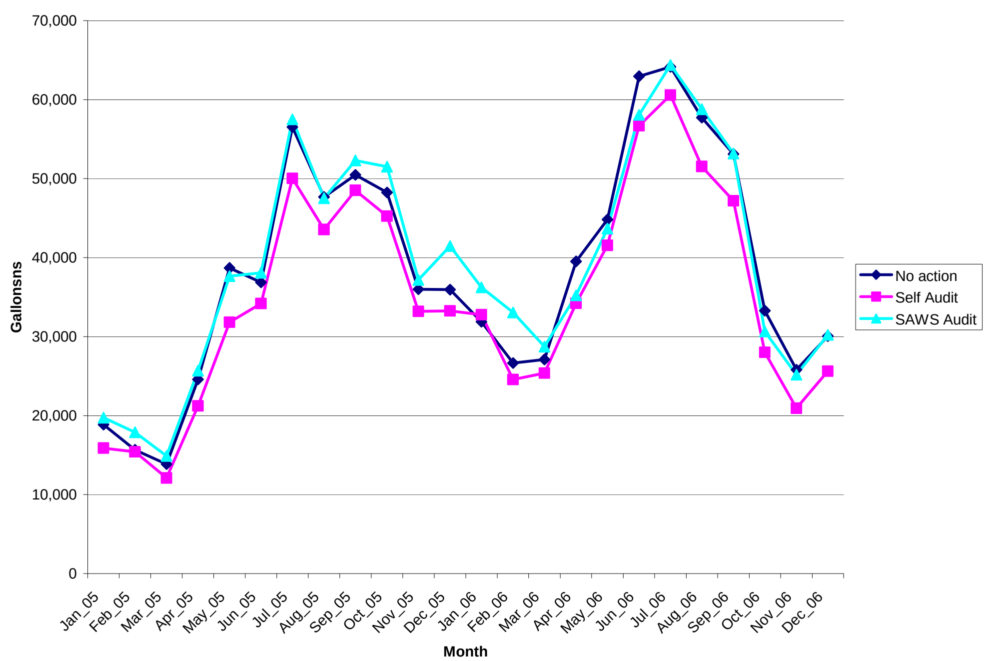


Figure 10: Average Monthly Consumption 2005-2006

In Table 5 the average for the five months following the study are shown. The no action group showed nearly the same reduction as the comparison neighborhoods and can be associated with the savings due to drought restrictions. When compared to the average consumption of July of the entire group of 60,000 gallons per month the Self Audit group showed a 5% consumption reduction and the SAWS Audit group showed approximately a 9% reduction.

Table 5: Average Monthly Consumption Reduction by Group

	Monthly Reduction	Total Reduction
No Action	843.3228956	4216.614478
Self Audit	3099.473171	15497.36585
SAWS Audit	5199.095082	25995.47541

Table 6 shows the average consumption reduction for the two comparison neighborhoods during the same period. One neighborhood, showed nearly the same reduction 1,000 gallons to 843 gallons for the no-action group. Additionally, one neighborhood showed increased consumption during the same period. This neighborhood represents the most affluent neighborhood in San Antonio where drought restrictions are difficult to enforce in this gated community.

Table 6: Comparison Neighborhood Consumption

	Taps	Average Monthly Reduction per residence
Tract 191803	2072	(2937.39)
Tract 19501	2389	1064.24

Regression analysis and ANOVA test were run to look for a relationship between the reductions from each of the groups compared to the pre-study consumption. Figures 11 and 12 show this relationship. The R squared value is small which shows a weak relationship although the relationship is significant with a p-value < .05 Figures 13 and 14 show the results of the SAWS audit regression analysis with a R squared value of .538 which shows a fairly strong relationship.

Table 7: Regression Analysis for Self Audit

Model	R Self Audit = Yes (Selected)	R Square	Adjusted R Square	Std. Error of the Estimate
1	.304[a]	.092	.050	18436.981

a. Predictors: (Constant), Aug_06, Dec_06, Oct_06, Sep_06, Nov_06

Table 8: ANOVA for Self Audit

ANOVA[b,c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.7E+009	5	739734536.5	2.176	.062[a]
	Residual	3.6E+010	107	339922252.8		
	Total	4.0E+010	112			

a. Predictors: (Constant), Aug_06, Dec_06, Oct_06, Sep_06, Nov_06

b. Dependent Variable: AvgGallons

c. Selecting only cases for which Self Audit = Yes

Model Summary

Model	R SAWS Audit = Yes (Selected)	R Square	Adjusted R Square	Std. Error of the Estimate
1	.734[a]	.538	.525	13598.756

a. Predictors: (Constant), Dec_06, Sep_06, Oct_06, Nov_06, Aug_06

Figure 11 Regression Analysis of SAWS Audit

ANOVA[b,c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.7E+010	5	7412629827	40.084	.000[a]
	Residual	3.2E+010	172	184926165.9		
	Total	6.9E+010	177			

a. Predictors: (Constant), Dec_06, Sep_06, Oct_06, Nov_06, Aug_06

b. Dependent Variable: AvgGallons

c. Selecting only cases for which SAWS Audit = Yes

Figure 12 ANOVA for SAWS Audit

3.3 Conservation Technician Interview

One of the Conservation Technicians in the Water Conservation Department was interviewed following the study to identify observations from the field. The conservation technician was a trained auditor of irrigation systems as well as familiar with indoor appliances. Most customers were very receptive to having the technician complete an audit. The technician stated that a majority of the problems found through the audits were related to irrigation problems (75%). Based on this interview of the time and equipment necessary to complete an audit it was estimated that each audit cost on average $43.

3.4 Estimation of Costs

Costs were developed in conjunction with San Antonio Water System Staff. The cost for materials, labor, and mileage were included in the calculations. The costs were then multiplied by the number of participants in each group. The amount of water saved from the no-response group was subtracted from the total to account for the effect of drought restrictions.

Every conservation program offered by the San Antonio water system is evaluated on annual basis for cost per acre foot of water saved in terms of what it would cost to secure the supply from an alternative source. In San Antonio where the cost of leasing an acre-foot is approximately $5,250, the costs of this program were significantly less. A conservation program was considered to be effective if the cost per acre foot remains below $700. Based on this analysis the Top 1% program was considered to be an effective program.

Estimation of Cost

Cost per packet = Postage + Staff Time + Cost of materials

Cost per packet = $ .37 + Staff Time + $.03 = $.40

Cost per Self-Audit = Staff time[1] + (free publication)[2] + Cost per packet

Cost per Self-Audit = $.46 + $4.50 + $.37 + $.40 = $ 5.73

Cost per visit = Gasoline[3] + Staff Time[4] + Materials[5] + Cost per Packet

Cost per Visit= $8.9 + $24.62 + $10 + $.40 = $43.92

Cost per Acre/ft Self-Audit = Cost Per ($5.73) * Total # (123) = $704.79/ Gallons (1,906,176 – 103,689) * Gal/Acre ft (325000) = **$127.08/ acre ft**

Cost per Acre/ft SAWS Audit = Cost Per (43.92) * Total # (183) = $8037.36 / Gallons (4,757,172 – 154,269) * Gal/Acre ft (325000) = **$567.50/ acre ft**

[1] 4 hr at $14 per hour = $56 / 123 Total = $.46
[2] Landscape Care Guide = 4.50 + $.37
[3] Assuming 20 miles of driving at .445 per mile (government mileage reimbursement) = $8.9
[4] Assuming scheduled visit time of 1 hour, plus 30 minutes drive time ($16.41 * 1.5hrs = 24.62)
[5] Low Flow Appliances, Pamphlets, Landscape Care Guide ($10)

4. CONCLUSION

Evaluating the five months of collected data for the top 1% users following the audits the three thesis questions can be answered.

Question 1: What effect on consumption, if any, does notification have on targeted residential water users?

All of the customers that received a packet identifying them as a top users had their consumption tracked pre and post notification. The results of the study showed that this group saved 843 gallons per month. During the month prior to sending out the packets this group used an average of 62,963 gallons showing a 1% reduction in use during the study period.

Question 2: What effect on consumption, if any, did completion of a self-checklist have on targeted residential water users?

All of the customers that received a packet identifying them as a top users had their consumption tracked pre and post notification. The results of the study showed that this group saved 3,100 gallons per month. During the month prior to sending out the packets this group used an average of 56,703 gallons showing a 5% reduction in use during the study period.

Question 3: What effect on consumption, if any, did a completed SAWS audit have on targeted residential water users?

All of the customers that received a packet identifying them as a top users had their consumption tracked pre and post notification. The results of the study showed that this group saved 5,200 gallons per month. During the month prior to sending out the packets this group used an average of 58,070 gallons showing a 9% reduction in use during the study period.

The two groups that responded to the self-audit or those who had a home audit performed showed a significant savings during drought conditions in San Antonio. The amount of water saved per customer was impacted in neighborhoods which historically have high consumption. Based on the cost of $127 per ac/ft for a self-audit and $567 ac/ft for SAWS audits the program showed cost-effective savings. While the cost may be slightly higher than alternative conservation programs, these costs reflect the ability to achieve almost a 9% consumption savings during drought conditions in San Antonio.

LITERATURE CITED

Dalhuisen, J. M., R. J. G. M. Florax, H.L.F. de Groot, and P. Nijkamp, 2003. Price and Income Elasticities of Residential Water Demand: A meta-analysis" *Land Economics* 79(2): 292-308.

Dewess, A., 2005. *Improving Landscape Irrigation Efficiency with ET calculations, Aerial Photography, and On-Site Evaluations.*, Water Conservation Division, Austin Water Utility, Austin, TX.

Diamond, R. A. 2003. *Project Review of the Irvine ET Controller Residential Reduction Study*, Irvine Ranch Water District. Irvine, California.

Freese and Nichols Inc., 2006. *2006 Region C Water Plan*. Texas Water Development Board, Austin, Texas.

HDR Engineering Inc., 2006. *2006 South Central Texas Regional Water Plan*. Texas Water Development Board. Austin, Texas.

Kenney, D.S., R. A. Klein., and M.P. Clark, 2004. Use and Effectiveness of Municipal Water Restrictions During Drought Restrictions in Colorado. *Journal of the American Water Resources Association* 40: 10.

Little, V. L., R. Gallup., 2003. *Evaluation and Cost Benefit Analysis of Municipal Conservation Programs*, Water Conservation Alliance of Southern Arizona. Tucson, Arizona.

Mayer, P. W., W. B. De Oreo., E. M. Opitz, J. C. Kiefer, W. Y. Davis, B. Dziegielewski, J. O. Nelson, 1999. *Residential End Uses of Water Report*, *American Water Works Association*. Denver, CO.

U.S. Census Bureau. 2005. San Antonio Population. http://www.census.gov/ *accessed* May 2007.

APPENDIX A

SELF AUDIT CHECKLIST

San Antonio Water System

Home Water Conservation Checkup

Before starting your checkup, make sure no one in the home is using water, including washing machines, dishwashers, etc.

Is the leak indicator — the red triangle on the face of the meter — moving? ❑ Yes ❑ No

Meter reading at start of checkup: __________
Meter reading at end of checkup: __________

General Leak Detection

If you have an irrigation system, locate and turn off the master control valve.

Does the leak indicator on your water meter stop moving? ❑ Yes ❑ No

Check for indication of a leak in the supply line, which typically makes a straight path from the meter to the house. Visible signs of a leak include:

❑ Water in the meter box
❑ Wet or green spots between meter and house
❑ Raised areas or depressions
❑ Other ____________________________
____
____

Check all outdoor water spigots. Are there visible signs of a leak? ❑ Yes ❑ No

Check around the foundation and other potential sources of outdoor leaks such as pools, hot tubs, fountains, etc. Are there visible signs of a leak?
❑ Yes ❑ No

Toilets

Do you hear the toilet running periodically?
❑ Yes ❑ No

Is the toilet flapper in good working condition?
❑ Yes ❑ No

Faucets

Are there any noticeable leaks at any of the faucets or under the sinks? ❑ Yes ❑ No

Tubs And Showers

Are there any noticeable leaks? ❑ Yes ❑ No

Irrigation System

Number of zones: _______
Is the irrigation system controlled by a timer?
❑ Yes ❑ No

Are zones timed separately? ❑ Yes ❑ No

How many days per week do you irrigate?_______

Irrigation Type

Check all that apply:

❑ Rotary Spray ❑ Pop-Up Spray
❑ Micro-Irrigation ❑ Drip Irrigation

Irrigation Maintenance Issues

❑ Sunken Heads ❑ Clogged Heads
❑ Not Vertical ❑ Misaligned ❑ Broken Heads
❑ Vulnerable Heads ❑ Blocked Heads
❑ Low Pressure ❑ Underground Leak
❑ Overspray to Impervious Surface (such as driveways, sidewalks, etc.)

Customer Information

____
Customer Name

____
Service Address ZIP

____
SAWS Account Number

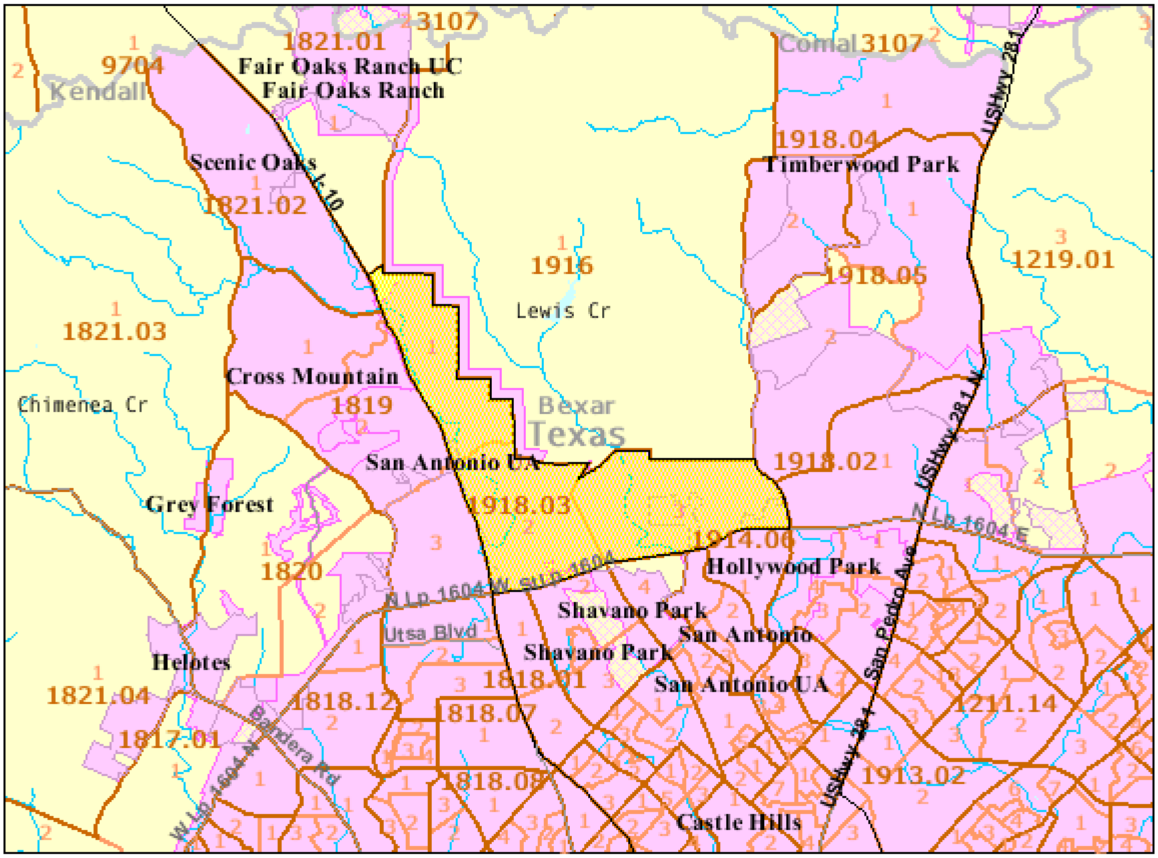
____
Customer Signature Date

San Antonio Water System • 2800 U.S. Hwy 281 North • P.O. Box 2449 • San Antonio, TX 78298-2449
210.704.7297 • www.saws.org

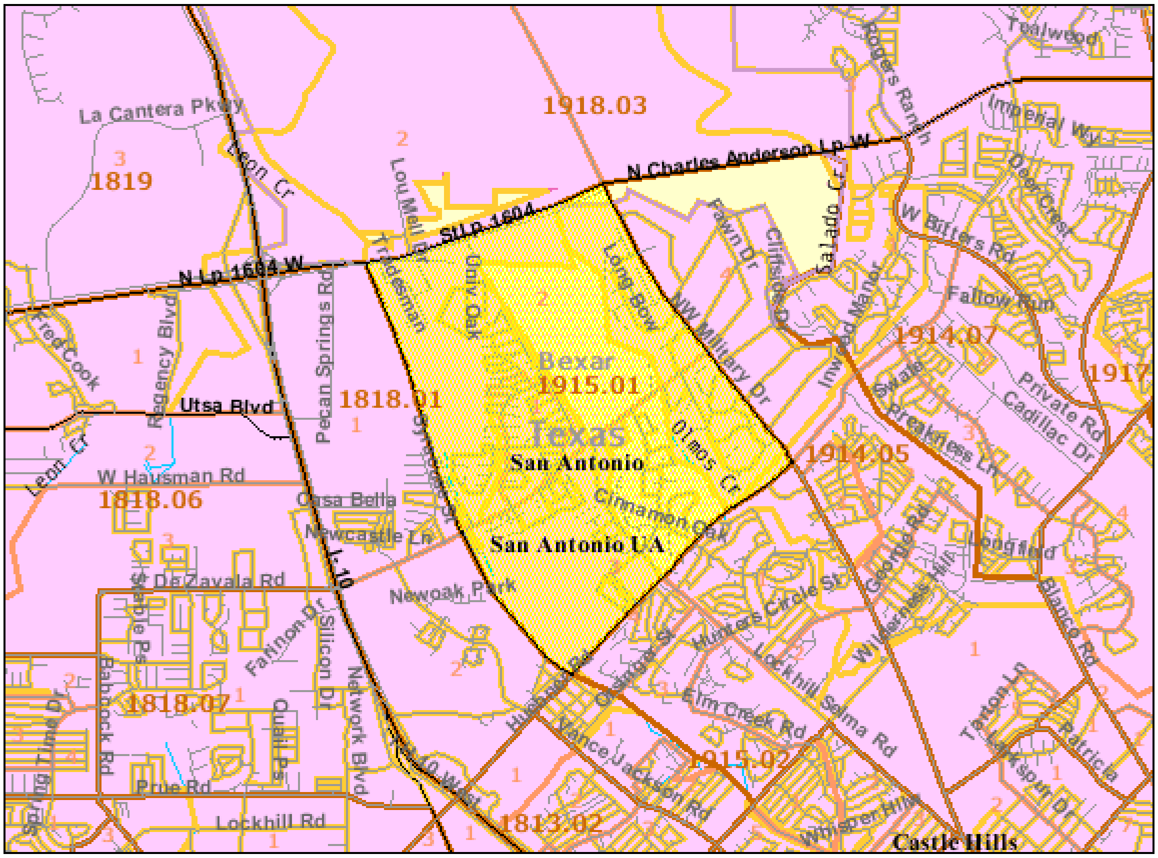
Rev. 7/20/06

APPENDIX B

COMPARISON NEIGHBORHOODS



APPENDIX B cont..



VITA

Name:	Jeremy Joseph Rice
Address:	Department of Recreation, Parks, and Tourism Sciences c/o Dr. Ronald Kaiser Texas A&M University College Station, TX 77843-2261
E-mail Address	jjr@freese.com
Education;	B.S. Renewable Natural Resources Texas A&M University, 2005 M.S. Water Management and Hydrological Science Texas A&M University, 2009